Moderation of effects of AAC based on setting and types of aided AAC on outcome variables: An aggregate study of single-case research with individuals with ASD

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Abstract

Objective: The purpose of this meta-analysis was to evaluate the potential moderating effects of intervention setting and type of aided AAC on outcome variables for students with autism spectrum disorders.

Methods: Improvement Rate Difference, an effect size measure, was used to calculate aggregate effects across 35 single case research studies.

Results: Results indicated that the largest effects for aided AAC were observed in general education settings. With respect to communication outcomes, both speech generating devices and the Picture Exchange Communication System were associated with larger effects than other picture-based systems. With respect to challenging behaviour outcomes, SGDs produced larger effects than PECS.

Conclusion: This aggregate study highlights the importance of considering intervention setting, choice of AAC system, and target outcomes when designing and planning an aided AAC intervention.

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Introduction

Literature review and statement of the problem

Children with autism spectrum disorders (ASD) present unique skill deficits in communication that require specialized, intensive intervention [1]. Research and educational policy emphasize the importance of using evidence-based interventions to address skill deficits for individuals with disabilities. Both the US No Child Left Behind act (2001) and the Individuals with Disabilities Education Act (2004) require that school-based interventions be based on peer-reviewed research (20 U.S.C 1414 §614, p. 118). Much of the research on interventions for individuals with ASD has been evaluated using single-case research designs. To assist in determining what constitutes evidence-based practises, researchers have developed guidelines and quality standards for designing and evaluating single case experimental studies [2,3].

Evaluating the evidence base for an intervention requires aggregating results from numerous studies, in this case, single-case research studies, in order to examine the quality of research and the effectiveness of the intervention on the target outcomes. To facilitate the evaluation of single-case research, recent developments in the use of meta-analysis to aggregate and evaluate a body of single case research have been made [4]. Meta-analysis is a particularly useful methodology for determining for whom, in what contexts, and dependent on what intervention variables particular interventions are effective. Answers to these questions are essential not only for moving the field forward, but for guiding practitioners as they make critical decisions about the education and treatment of individuals with ASD [5]. Having information

about the characteristics of students who are likely or unlikely to benefit from a specific intervention may facilitate students receiving effective interventions more effectively and efficiently than in the traditional trial-and-error method. Additionally, knowing if research has shown an intervention to be successful in a given environment can inform practitioners as they consider what interventions to put in place in various learning contexts. Finally, having research support for whether a particular intervention is likely to produce the desired changes in targeted student outcomes could increase the efficiency and effectiveness of the intervention selection process. Addressing these issues is particularly relevant with respect to the use of augmentative and alternative communication (AAC) for students with ASD.

AAC refers to a continuum of communication supports for individuals who lack functional speech [6]. Such supports may function to facilitate, or augment, the intelligibility of an individuals' speech or in some cases may provide an alternative means for the individual to communicate. AAC is divided into two categories: unaided and aided [7]. Unaided AAC does not require the use of any additional resources that are not already present within the individual. Examples include manual sign or gestures. One benefit of the use of unaided AAC is that the individual is always in possession of the tools needed to communicate. Therefore, they always have the means of attempting communication. A drawback to the use of unaided AAC is that the listener may not be familiar with manual sign or specific gestures, which may result in a communicative breakdown [8]. Unaided AAC may also present unique challenges for students with ASD, as many present with fine motor, and motor imitation difficulties [9].

On the other hand, the use of aided AAC has been shown to be successful in promoting functional communication for students with ASD [10,11]. Aided AAC involves the use of supplemental materials or equipment to improve an individual's functional communication [7].

Examples of aided AAC include communicating with a picture-based system, using an object or symbol, writing a message with a keyboard or paper and pencil, or utilizing a speech generating device (SGD). Aided AAC typically only requires the learner to engage in a single response (such as pointing) which may not only speed up the acquisition of the AAC system [12] but may also lead to new communication opportunities and generalization of the use of the AAC system to novel situations [13].

Picture-based communication systems, the Picture Exchange Communication System (PECS), and SGDs are all types of aided AAC that have been evaluated for use with persons with ASD [11]. Picture-based communication systems involve teaching students to locate a picture(s) representing the message they wish to convey (typically a request) and point to it or exchange that picture for the item they are requesting. Previous research has suggested that picture-based communication systems have produced moderate effects on communication for student with ASD [11].

PECS is a specific type of picture-based communication system which has been used to provide an alternative form of expressive communication for nonverbal children with ASD [10]. Unlike other picture-based communication systems, PECS is manualized, having an intervention protocol that consists of six phases of intervention, each with explicit instructional procedures [11]. Previous studies on the use of PECS for students with ASD have found PECS to be a promising intervention practice for children with ASD that can lead to functional communication [14,15]. Additionally, PECS has been shown to be more effective than other picture-based communication systems and as effective as SGD in promoting functional communication for learners with ASD [11].

Several recent literature reviews and meta-analyses have investigated the implementation of PECS with individuals with ASD and other disabilities [16]. The literature reviews, which are limited in that they did not provide statistical analyses of results, suggested that PECS has limited or better positive outcomes on functional communication skills [16,17,18]. Of the meta-analyses, several used the percent of non-overlapping data (PND), or other outdated effect size measures, finding evidence of impacts on functional communication, though less on collateral effects [19,20]. For example, Flippin, Reszka, and Watson [14] assessed the effects of PECS on communication skills for children with ASD and found small to moderate effects for young children. Tincani and Devis [21] had similar findings and additionally reported that PECS was found to be effective across settings. However, comparisons of the effects of PECS versus other aided AAC systems was not evaluated and because effect sizes were calculated using percent of non-overlapping data [22], which does not provide confidence intervals, the reader is left without a means to determine the level of confidence in the results and without a means to make comparisons regarding moderating variables [23,24].

PECS has also been evaluated for use with individuals with ASD in a meta-analysis using the improvement rate difference (IRD) effect size measure, which found that PECS had a greater impact on functional communication than other outcomes (i.e., challenging behaviour, speech, and academic skills), had a greater impact on functional communication in preschool-aged children than others, and was most effective with students who had completed the most phases of PECS instruction [25]. Although these articles provided valuable information regarding the efficacy of PECS, they did not provide information regarding comparisons between types of aided AAC and most did not provide information regarding settings in which PECS was found to be more or less effective.

SGDs are another commonly used form of AAC for students with ASD. An SGD is a portable electronic device that produces a pre-recorded or digitized verbal message [6]. An individual can use an SGD to request, to label or comment, to ask questions, or to answer questions [26,27]. Traditionally, SGD have been self-contained, electronic devices whose sole purpose was to produce verbal speech output. Recently, however, the use of SGD applications on tablet computers has become a common practice for students with developmental disabilities [28] (Kagohara, et al., in press). One literature review has focused on the use of SGDs with children with ASDs [29]. They found communication intervention was provided to children between the ages of 3 and 16 years and was most often conducted in school settings, though some studies took place in participants' homes or in a community or hospital setting. However, their review was narrative in nature; thus, it did not provide effect size measures or identify variables that may have moderated intervention effects.

Several meta-analyses have investigated the effects of the use of aided AAC with individuals with ASD. Two [30,31] investigated the impact of AAC on speech in children with autism, using PND. They found that AAC may have moderate impacts on speech in some children. More recently, two meta-analyses used the improvement rate difference (IRD) [4] effect size to investigate the use of aided AAC with individuals with ASD [11,32], including investigation of differential effects of AAC based on disability category and age [11]. IRD has several advantages over PND and other single-case effect sizes, including the availability of confidence intervals via which to make comparisons and determine the precision of the IRD scores [4]. These studies demonstrated that AAC has overall strong effects on outcomes for individuals with ASD and, when differential effects on dependent variable categories were investigated, very strong effects were found for communication skills, which were significantly

higher than effects for social skills and challenging behaviours, though still moderate to strong effects were found in those areas [11]. Further, Ganz, Earles-Vollrath, et al. [11] made overall comparisons across types of AAC, finding stronger effects for SGDs and PECS than for other picture-based AAC. That is, overall AAC effects on categories of outcomes have been evaluated and effects of individual types of AAC on overall outcomes have been investigated, but differential impacts of individual types of AAC on individual categories of dependent measures have not been investigated in fine detail.

None of the previous AAC meta-analyses have evaluated the potential moderating effects of the setting in which the AAC intervention was implemented. Contextual factors can vary considerably from one educational setting to another. For example, in a self-contained special education classroom for students with autism, there is typically a lower student to teacher ratio which may facilitate the exchange of pictures, or the audibility of an SGD. In a larger general education communication attempts with AAC may be more difficult for listeners to attend to, or reinforce. Determining if setting moderates the effect of the AAC intervention is important to consider when designing and planning for intervention.

Purpose and research questions

The purpose of this aggregation of single-case research is to provide insight regarding moderators of the effects of aided AAC on individuals with ASD; particularly in regard to setting, type of AAC, and outcome variables. Research questions include: (a) is setting (e.g. general education classroom, special education classroom, therapy room) a moderator for effectiveness of AAC implementation; and (b) do different types of AAC (e.g. PECS, SGDs) have differential impacts on categories of outcome variables (e.g. communication skills, social skills, academic skills, challenging behaviours)?

Method

Literature search

The literature search was conducted as specified by Ganz, Earles-Vollrath, et al. [11], with an expansion of the search to include more recent literature. The following online databases were searched to find literature published between 1980 and September of 2011: ERIC, PsychINFO, Education Full Text, Professional Development Collection, and Social Sciences Full Text. The searches were limited by using the following keyword terms: *autis*, autism spectrum disorder*, ASD, pervasive developmental disorder*, PDD, PDD-NOS, Asperger*, Asperger syndrome*, and Asperger's syndrome, which were each combined with each of the following keywords: AAC, augmentative communication, alternative communication, augmentative and alternative communication, PECS, and Picture Exchange Communication System. A total of 292 items were found in total, including peer-reviewed journal articles, books and chapters, dissertations, and other types of literature.

Procedures

Each piece of literature found was assessed; two independent raters evaluated 72% of the items. The following criteria, based on Ganz, Earles-Vollrath, et al. [11], were considered for each item: (a) included at least one participant with an ASD diagnosis (i.e., autism, PDD-NOS); (b) outcomes measured included academic skills, challenging behaviour, communication skills, and/or social skills; (c) aided AAC interventions were investigated as an independent variable; (d) single-case research designs that demonstrated experimental control (e.g. reversal, multiple-baseline, alternating treatment) were included; (e) line graphs were provided; (f) documents were research articles published in refereed journals; and (g) documents were in English. Documents that failed to meet all of the inclusion criteria were excluded.

Disagreements regarding inclusion criteria were handled either by having a third reviewer rate the document, resulting in a determination based on the majority of the raters, or in discussion between the two raters until consensus was reached. Excluded documents were primarily dissertations, journal articles that were not reports of research, and research designs that were not experimental (e.g. A-B designs); three additional articles were later excluded due to a lack of baseline data with which to compare intervention effects, the independent variable was a combination of AAC and speech instruction, and for one article, a more thorough reading lead to the discovery that the research design was not experimental. Once articles were selected for inclusion, a manual search of the references of those articles was conducted to search for additional articles meeting the inclusion criteria. Thirty-five articles met the final inclusion criteria and were evaluated via meta-analytic procedures.

Data extraction

The included articles were coded based on study characteristics. For the purposes of this meta-analysis, articles were coded for setting in which AAC was implemented, type of AAC implemented, and type of outcome variable measured. Levels of the setting moderator coded included home; general education classroom (including settings that were 'integrated', or had multiple students with disabilities and multiple general education students); special education classroom; therapy room; hospital; outdoors; and varied (i.e., the study noted that the settings fit many of the above levels and data could not be separated into a single level). Categories of type of AAC included PECS, SGDs, and other picture-based AAC. Categories of outcome variable included communication skills (e.g. using the AAC device independently, speaking), social skills (e.g. play, social approach), academic skills (only spelling was evaluated in the included studies), and challenging behaviours (e.g. tantrums, crying).

Effect size analysis

The single-case effect size, the Improvement Rate Difference (IRD; Parker, Vannest, & Brown, 2009) was used to measure the effect, or magnitude of change, between baseline and intervention (generalization and maintenance data were excluded). IRD provides a metric of the effects, or change in magnitude, that is differences, between data scores in baseline versus intervention. Parker et al. (2009) provide instructions for calculating IRD by hand. Scores for IRD range from 0 to 1.00, with .50 indicating chance performance and 0 indicating no improvement. Scores may be interpreted in the following ranges: below .50 signifies questionable effects, between.50 and .70 denotes moderate effects, and.70 or .75 or higher implies strong or very strong effects. Confidence intervals (CIs) and *p* values were calculated to indicate accuracy and reliability of calculated IRD values.

Inter-rater agreement for IRD calculations

Each of the included studies had more than one IRD score, due to the inclusion of multiple clients, conditions, or outcome variables. Altogether, there were 274 individual IRD scores. Fifty-three percent of the IRD cells (number of high and low data points for baseline and intervention phases) were calculated by two independent raters. Overall inter-rater agreement (number of agreements divided by the total number of IRD scores, multiplied by 100) resulted in an inter-rater agreement of 88%. Ratings were compared within the first 20 calculations and disagreements were discussed by both raters and recalculated until agreement was reached for 100% of the scores. These disagreements were due to crowded graphs that were hard to interpret and rater counting errors.

Results

Differential effects moderated by setting

Studies that indicated in what setting AAC was implemented were examined to compare effects. Categories were determined according to what type of setting was specified in each article's narrative. Figure 1 provides a forest plot illustrating the results for home, general education classroom, special education classroom, and therapy room settings.

Insert figure 1 about here

Home settings had 55 separate effect sizes from 11 studies (IRD = .67<<.70>>.73); the aggregated IRD score indicates moderate effects. General education classroom settings had 16 separate effect sizes from 5 studies (IRD = .80<<.84>>.87); the aggregated IRD score indicates strong effects. Special education classroom settings had 125 separate effect sizes from 17 studies (IRD = .69<<.71>>.73); the aggregated IRD score indicates moderate to strong effects. Therapy room settings had 40 effect sizes from 5 studies (IRD = .62<<.66>>.70); the aggregated IRD score indicates moderate effects. As illustrated in figure 1, the lack of overlap between general education and all other settings indicates that the difference between those mean IRD scores was statistically significant (p<.05). That is, when AAC was implemented in general education settings, participants performed significantly better than when implemented in any other settings. The overlap between the other three settings (home, special education classrooms, and therapy rooms) indicates no statistically significant difference between any of those settings. Due to the relatively small number of studies included in the general education and therapy room categories, albeit an acceptable number of separate IRD scores, those results should be viewed with some caution.

Although some articles reported implementing AAC in a hospital or outdoor setting, these were excluded from the analysis because they resulted in only 2 and 4 IRD scores, respectively, which is too few to draw conclusions. Further, studies for which varied settings

were indicated without clarification regarding which data points were implemented in which settings were also excluded from the comparative analysis because the category is too broad and has too much overlap with the other categories to be useful for comparison purposes.

Differential effects of three types of AAC on categories of outcome variables

Types of AAC were broken down by effects on categories of outcome variables to determine whether or not particular AAC interventions are more or less effective on particular outcome variables; these results are illustrated in figure 2. PECS and communication had 96 separate effect sizes from 15 studies (IRD = .71<<.73>>.75); the aggregated IRD score indicates moderate to strong effects. SGDs and communication had 75 separate effect sizes from 8 studies (IRD = .69<<.71>>.74); the aggregated IRD score indicates moderate to strong effects. Other picture-based AAC and communication had 37 separate effect sizes from 7 studies (IRD = .53<<.58>>.62); the aggregated IRD score indicates moderate effects. PECS and challenging behaviour had 10 separate effect sizes from 2 studies (IRD = .51<<.59>>.66); the aggregated IRD score indicates moderate effects. SGDs and challenging behaviour had 6 separate effect sizes from 2 studies (IRD = .74<<.83>>.92); the aggregated IRD score indicates strong effects. PECS and social skills had 7 separate effect sizes from 2 studies (IRD = .70<<.77>>.85); the aggregated IRD score indicates moderate to strong effects. SGDs and academics had 30 separate effect sizes from 2 studies (IRD = .61<<.66>>.71); the aggregated IRD score indicates moderate effects.

Insert figure 2 about here

As illustrated in figure 2, in comparisons of effects on communication skills, the overlap between PECS and communication and SGDs and communication indicates that there were not significant differences (p<.05). However, both were found to be statistically significantly more

effective than other picture-based AAC and communication. Regarding challenging behaviour outcomes, SGDs were found to be statistically more effective than PECS.

When comparing combinations related to PECS, overlap between PECS and communication and PECS and social skills does not indicate statistical significance; however, both PECS and communication and PECS and social skills were demonstrated to be statistically more effective than PECS and challenging behaviour. That is, PECS was found to be more effective in improving communication and social skills than challenging behaviours. In evaluating the effect of SGDs on outcome variables, the slight overlap between the confidence intervals for SGDs and communication and SGDs and challenging behaviour indicates no significant difference. Confidence intervals for SGDs and challenging behaviour did not overlap with those for SGDs and academics, indicating that SGDs were more effective in improving challenging behaviours than academic skills (spelling). SGD implementation for communication and academics had overlapping confidence intervals, indicating no significant difference. The narrow confidence and large number of studies included in the communication skills comparisons lead to confidence in these results; however, the results in relation to challenging behaviour, social skills, and academic skills must be viewed with less confidence due to the limited number of studies included in each combined category.

When broken down by outcome measure assessed, only SGDs were evaluated in combination with academic skills because neither of the other types of AAC included studies evaluating academics. Only PECS was evaluated in combination with social skills because neither of the other types of AAC included studies evaluating this outcome variable. Other types of picture-based AAC were excluded from the analyses combining AAC with social skills,

academic skills, and challenging behaviour because, only 2, 0, and 5 IRD scores were available for those combinations, respectively.

Discussion

The purpose of this meta-analysis was to identify factors, specifically (a) setting, and (b) differential effects of specific types of AAC on specific categories of targeted outcomes for participants with ASD. Despite the extant literature base on this topic, including several recent meta-analyses [11,30,31,32], exploration of these factors has not previously been addressed. This study addressed these gaps in the literature base, providing further information regarding specificity of effects necessary for making contextual implementation decisions and choosing the most appropriate AAC intervention for the targeted outcome being addressed.

The first research question addressed whether the setting in which the AAC intervention is carried out differentially impacts the magnitude of effect on targeted outcomes. Although moderate to strong effects were obtained for all settings, including home, general education classroom, special education class, and therapy room, results indicated that setting does moderate the effectiveness. AAC interventions implemented in the general education setting yielded the strongest effects. Given that students with ASD integrated into a general education setting are typically higher functioning, these differential results may be more indicative of the skill level of the participants receiving the AAC intervention in the general education classroom than the impact of the setting itself. Additionally, the general education environment may be more conducive to interactions given the larger number of peers, which provides more opportunities for communication and potentially an increased motivation to communicate. These results were promising as they indicated AAC to be effective across educational settings. Further, the results

indicated AAC to be an efficacious communication support in the general education environment, potentially facilitating successful academic and social inclusion.

Considering types of AAC, this meta-analysis also sought to determine if type of AAC (i.e., PECS, SGDs, or other picture-based AAC) differentially impacted effects by category of targeted outcomes, specifically communication, social skills, academics, and challenging behaviours. Results indicated that targeted outcomes did moderate the magnitude of change both within and across types of aided AAC, specifically PECS, SGDs, and other picture based AAC interventions. Results indicated PECS to be more effective for addressing communication and social skills than for challenging behaviours, consistent with previous meta-analysis [25], whereas SGDs were found to be equally effective for addressing communication skills and challenging behaviours. As noted by Ganz, Davis, et al. [25], this is not surprising as PECS specifically aims to improve functional communication, which likely directly impacts communication and social skills and indirectly impacts challenging behaviours, yielding a smaller, though not insignificant, magnitude of change. Impact of PECS on academic skills and SGDs on social skills was not available due to the limited research utilizing these types of AAC for the specified skill. Results did indicate SGDs to be less effective for addressing academic skills than challenging behaviours, although this must be viewed with caution given the limited number of IRD calculations. Likewise, other picture based AAC interventions were found to be more effective for challenging behaviour than for addressing communication skills, however, given the limited number of study this must also be interpreted with caution.

Beyond the effectiveness of each type of AAC for specified targeted outcomes, the strongest impact of this study is the guidance provided for choosing the most appropriate aided AAC for the skill being addressed. Results indicated other picture-based AAC interventions were

less effective than PECS and SGDs for enhancing communication skills. At the time of this review, PECS was the only aided AAC intervention with substantial evidence for evaluating effects on social skills and results indicated a strong impact. Likewise, SGD interventions were the only aided AAC interventions with enough evidence for evaluating the magnitude of change on academic skills, yielding moderate change. Both SGDs and other picture-based AAC interventions were more effective for intervening with challenging behaviours than PECS for studies that met inclusion criteria, keeping in mind that this must be interpreted with caution due to the limited number of studies contributing to this comparison.

As is common with meta-analytical research, this study does present some limitations. Primarily, each aggregated IRD is comprised of a small number of obtained IRDs, particularly when broken down by categories and further desegregated based on combination of categories. Thus, the results must be viewed with caution and conclusive statements cannot be made. The second limitation is the meta-analysis is comprised of only published results; studies with less favorable results are unlikely to be included [33].

This study also assists in identifying areas in need of further exploration. More research to address the impact of PECS for directly enhancing academic performance is warranted. Likewise, more research exploring the utility of both SGDs and other picture-based AAC interventions for improving social skills is necessary to determine if these are viable intervention options. Additionally, exploring what intervention components, including with aided AAC as part of an intervention package, enhance the impact on targeted outcomes would provide further information for maximizing the benefits of these interventions for participants with ASD.

Declaration of interests. The authors report no conflicts of interests. The authors alone are responsible for the content and writing of this paper.

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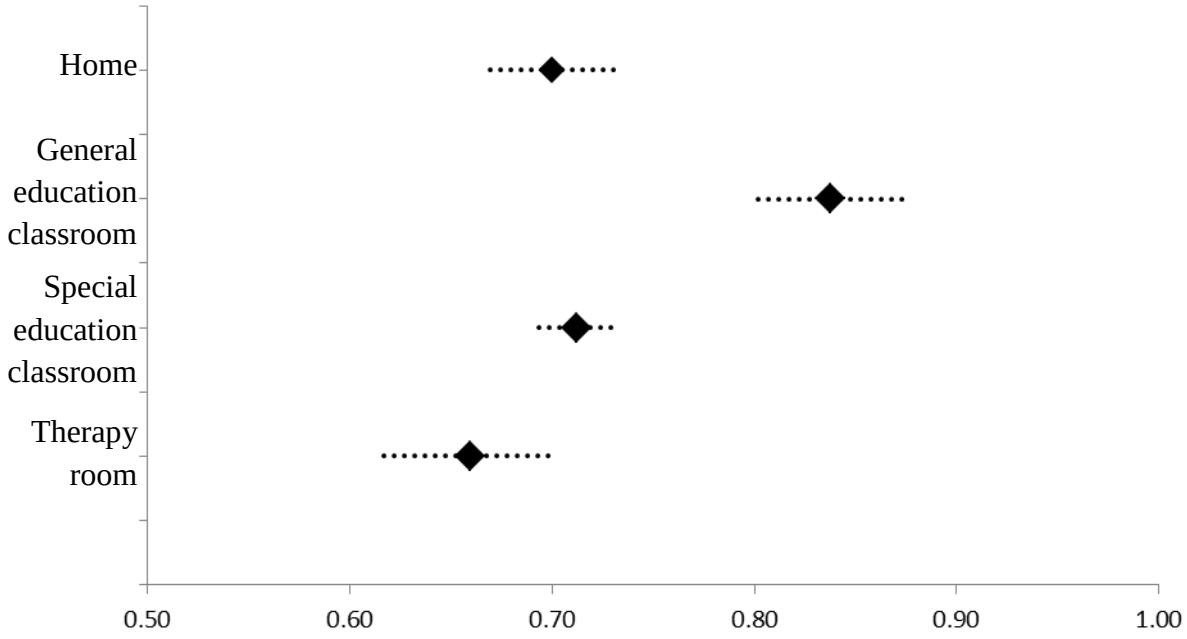

Figure 1. Forest Plot of Differential Effects by Setting: IRD Scores and Confidence Intervals.

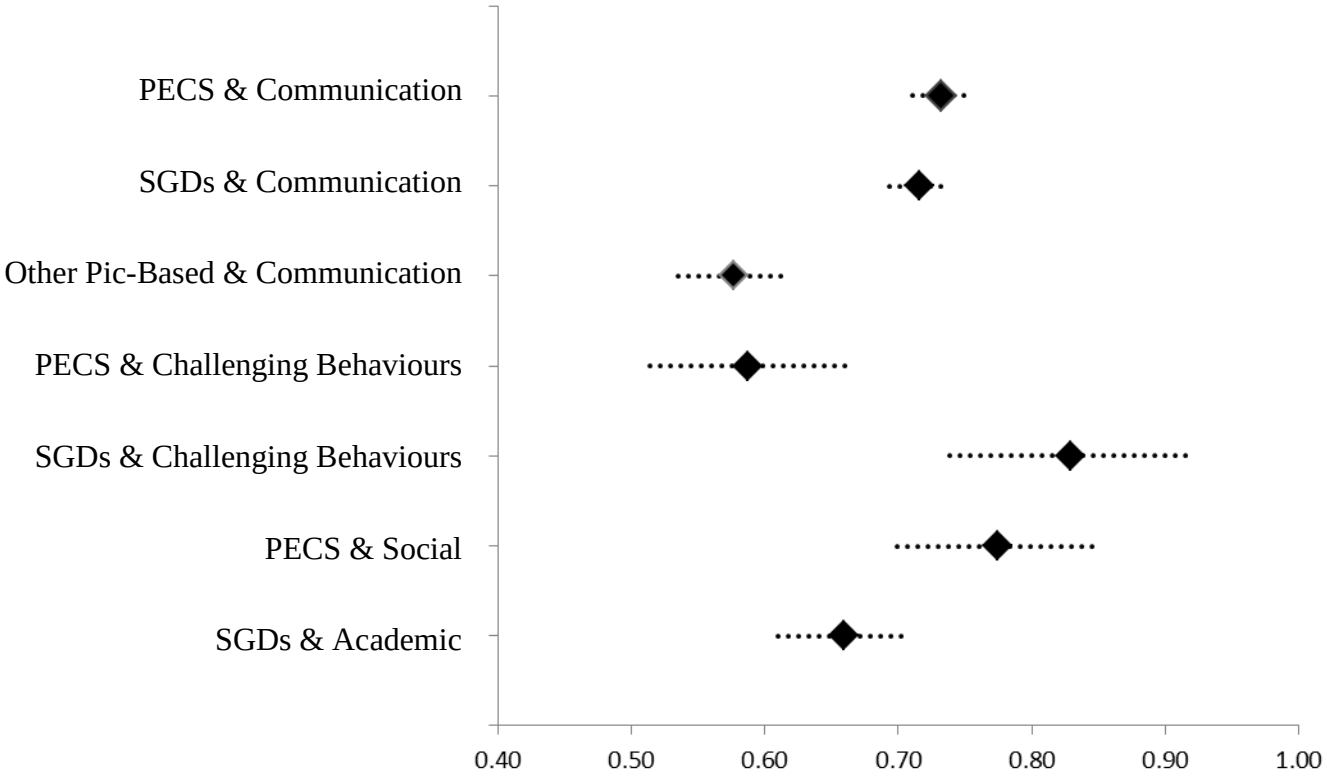

Figure 2. Forest Plot of Differential Effects of Type of AAC on Category of Outcome Variable: IRD Scores and Confidence Intervals.